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Situation Semantics: the ontological balance sheet *

Jonathan Ginzburg (ginzburg@dcs.kcl.ac.uk)
King's College, London

Abstract. One of the important challenges facing NL semantics in the early 21st century is to theoretically underpin analysis and generation of conversational interaction. I start by considering certain requirements a semantic framework needs in order to be viable for this task, with reference to a benchmark example. One fundamental requirement is the provision of an ontology which incorporates propositions, questions, and similar abstract entities. The main theme of this paper concerns the construction of such an ontology. I argue that Barwise and Perry's approach to ontology—including its nonstandard trichotomy distinguishing between situations/events, situation types, and propositions—provides useful building blocks. I implement the construction using the type theoretic framework developed by Cooper (this journal).

Keywords: situation semantics, situation theory, type theory, ontology, abstract entities

1. Situation Semantics in the 21st Century?

The scene pictured in figure 1 is taken from a virtual reality environment developed by (Institute for Creative Technologies, 2003). The conversational agents (the sergeant and medic) can engage in conversation with a human. One of the important challenges facing NL semantics in the early 21st century is to theoretically underpin analysis and generation of conversational exchanges like the multilogue (from (Traum, 2003)), which takes place in this scene:

(1) 1 L(ieutenant): What happened here?
2 S(ergeant): There was an accident.

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Figure 1. A situation in Bosnia

3 L: Who's hurt?
4 S: The boy and one of our drivers.
5 L: How bad is he hurt?
6 S: The driver or the boy?
7 L: The boy.
8 S: Tucci?
9 M(edic): The boy has critical injuries.
10 S: Understood.

I start by sketching an informal analysis of (1). To the best of my knowledge, no existing grammar fragment or implemented system can fully implement this analysis.[1] In this respect, examples like (1) can serve as benchmarks for contemporary semantic research. I will then suggest certain requirements a semantic framework needs in order to implement such an analysis—among other things, I will compare these with the perspective on semantics of 1980s situation semantics.

In (2) I provide partially de-contextualized paraphrases of the various utterances that make up the conversation:[2]

[1] The Mission Rehearsal Exercise system, (Institute for Creative Technologies, 2003), obviously comes closest, though for certain phenomena it makes use of heuristic-based techniques.

[2] Of course various aspects of these paraphrases reflect my theoretical biases. But I doubt any given paraphrase is particularly controversial.

(2) 1 L(ieutenant): What happened here? *L is asking what (situation/incident) happened in location* l_0.
2 S(ergeant): There was an accident. *S is saying that (the situation that happened in location* l_0*) was an accident .*
3 L: Who's hurt? *L is asking who's hurt in this accident*
4 S: The boy and our driver. *S is saying that* b_0 *and* d_0 *were hurt in this accident.*
5 L: How bad is he hurt? *L is asking how bad is he hurt*
6 S: The driver or the boy? *S is asking if L's 'he' refers to* b_0 *or does it refer to* d_0*?*
7 L: The boy. *L is saying that 'he' refers to* b_0.
8 S: Tucci? *S is asking Tucci to answer the question about how bad* b_0 *is hurt*
9 M(edic): The boy has critical injuries. (Tucci is saying that) b_0 has critical injuries.
10 S: Understood. *S is saying that he understands what Tucci has just said.*

Coming up with (2) involves tasks such as the following:

(3) a. An account of the verb 'happen'—presumably this is to be analyzed somehow as involving a relation between situations/events and spatio-temporal locations that extend into them; for some discussion see (Parsons, 1990).[3] The accident situation involved here serves as the 'domain' for utterances 3, 4

b. Indexicality is implicated in utterances (1, 3, 4, 5), e.g. in the resolution of 'here', 'he', 'the boy', and of course tense.

c. Metacommunicative meaning: (6) is a request for the clarification of (5). It involves a complex process in which ellipsis resolution combines with a grammatical device relating to disjunction and alternative questions. The ellipsis resolution involves constructing an appropriate predicate using material from the partially comprehended utterance (5); the interpretation of (10) involves the previous utterance as the argument of the predicate 'understand'.

d. Dialogue moves: none of the utterances involves an explicit performative ('I'd like to ask the following:', 'I claim that . . . ') and

[3] As Parsons points out, 'happen' does not introduce its own described situation—there is no separate happening event above and beyond the event/situation that happens.

yet, minimally, the force of any given utterance is as indicated ('L asks . . . ', 'S says that . . . ' etc)

e. Question/Answer dynamics is involved in the interpretation of utterances (2, 4, 7, 9). This includes the resolution of the short answers in (4,7) and the availability of the question raised in (5) to Tucci in utterance (9).

These tasks correlate with five requirements:

(4) a. A theory of external reality on the basis of which scenes like that depicted in (1) can be described.

b. A theory of how utterance meanings get anchored in speech events.

c. A theory of metacommunicative interaction.

d. A theory of dialogue moves.

e. A theory of dialogue context.

A semantic theory for the 21st century needs to integrate these various requirements. How does this relate to the work and accomplishments of situation semantics' original programme?[4]

Bringing situations into the picture was an important component of Barwise and Perry's program that involved developing tools for describing external reality in terms that can capture the resource-bounded nature of perception. Another key aspect of situation semantics, that has had a far lesser impact, is the utterance-based formulation of semantics initiated in *Situation and Attitudes*. Barwise and Perry argued that semantics should take utterances, spatio-temporally located speech events, as the entities whose contents it analyzes. Meanings, on this view, pertain to types of utterances. Indexicality is then accommodated directly as the dependence on features that characterize the speech event.

Classical situation semantics did not develop a theory of metacommunicative interaction, but it did provide important conceptual apparatus therefor. These components—the reification of utterances as

[4] A distinction came to be drawn between Situation *Theory* and Situation *Semantics*, the former pertaining roughly to logical aspects of the program, the latter to linguistic aspects. Given the rather small cardinality of people who engage in either at this stage, I will stick with the latter, which has the unfortunate property nonetheless of possessing an unusable two letter acronym. In its stead I will use the word *sitsemian*.

real world events and the view of meanings as abstracts over contextual parameters—are a vital basis for at least one theory of grounding and clarification potential (Ginzburg and Cooper, 2004).

Two other areas which classical situation semantics did not concern itself with are a theory of dialogue moves (known in an earlier epoch as speech act theory) and a theory of dialogue context. (see e.g. (Poesio and Traum, 1997; Ginzburg, 1996; Trindi Consortium, 2000; Asher and Lascarides, 2003)). What is common to these two areas, which are actually strongly integrated, is that they both presuppose ontologies which incorporate propositions, questions, and similar abstract entities.

The main theme of this paper concerns the development of such ontologies and how they can be integrated with the ontology of external reality envisaged by Barwise and Perry. I start by discussing briefly why the sitsemian approach to ontology provides useful building blocks for such ontologies. I then motivate an ontological trichotomy—the distinction between situations/events, situation types, and propositions. Finally, I sketch the construction of a semantic ontology using the type theoretic framework developed by Cooper (this journal).

2. Situation Semantics and Ontological Innovation

One of Situation Semantics' important contributions was the placing of ontological investigation at the centre of semantics. In this section I would like to review some of the main characteristics of this approach to ontology initiated in Jon Barwise's seminal 'Scenes and other situations' (Barwise, 1989a). A one sentence summary can be found in the following quote from Barwise and Perry (1983):

(5) The primitives of our theory are all real things: individuals, properties, relations, and space-time locations. Out of these and objects available from the set theory we construct a universe of abstract objects. (*Situations and Attitudes*, p. 178)

The theory has evolved over the years on two dimensions: which set theory to be used and the identity of the abstract objects. The initial set theory used was Kripke-Platek admissible set theory with urelements. Initially propositions were rejected as 'artifact(s) of the semantic endeavor' (*Situations and Attitudes*, loc. cit), though as Barwise and Perry (1985) admitted, this was not a move they were required to make. Indeed, propositions, *austinian* propositions, were the stars of *The Liar* (Barwise and Etchemendy, 1987), whose other significant

innovation was the use of Aczel's Non-Well-Founded set theory AFA (Aczel, 1988). The move to this richer ontology was instigated in part by an observation due to Soames (1986) that although logical omniscience can be defused merely by 'going partial', new variants of this problem arise for a situation-based approach. It is only by combining partiality with characterization of propositions employing structured objects that a defensible level of fine grain is achieved.

A key ontological innovation in post-1985 sitsemian work was the postulation of a trichotomy: situations v. situation types, also known as SOAs or infons,[5] v. propositions.

Briefly, situation types are structured objects that function as 'potential properties' situations can possess: situation types are taken to be structured from two components, a relation R, and an assignment α, which assigns real world entities to the argument roles of R, as in (6a). The notation in (6b) indicates that the situation s is of the type given by the situation type $\langle\langle R;\alpha\rangle\rangle$. If a situation fails to be correctly classified by a situation type σ, this is notated as in (6c).

(6) a. $\langle\langle CALM; loc : Jerusalem\rangle\rangle$

b. $s \models \langle\langle R;\alpha\rangle\rangle$

c. $s \not\models \langle\langle R;\alpha\rangle\rangle$

Situation types are assumed to come in positive/negative pairs, i.e. every relation/assignment pair gives rise to a positive situation type and a negative situation type. We will assume the positive ones to be (notationally) unmarked, and notate the corresponding negative with an 'overline', as in (7a). Because situations are partial, there is a difference between a situation failing to be correctly classified by σ and being correctly classified by $\overline{\sigma}$. For any situation s and situation type σ, (7b) holds, but (7c) generally fails:

(7) a. $s \models \overline{\langle\langle R;\alpha\rangle\rangle}$

b. Either $s \models \sigma$ or $s \not\models \sigma$

c. Either $s \models \sigma$ or $s \models \overline{\sigma}$

The intuition is that classifying s with $\overline{\sigma}$ means that s actually possesses information which rules out σ, rather than simply lacking

[5] I have been informed that in Dutch 'SOA' stands for sexually transmitted disease (Sexueel Overdraagbare Aandoeningen) and most semanticists treat them accordingly. The reintroduction of the term 'situation types' is related to our subsequent move to a type theoretic framework.

concrete evidence for σ. So, for instance, a situation I perceive in London s_{london} would typically neither be of the type $\langle\langle CALM; loc : Jerusalem\rangle\rangle$, nor of the type $\overline{\langle\langle CALM; loc : Jerusalem\rangle\rangle}$. s_{london} is simply indeterminate about the issue of Jerusalem's calamity or calmness.

Basic (i.e. non-compound) propositions are taken to be structured objects, whose immediate components are a situation s and a situation type σ, notated *inter alia* as $prop(s, \sigma)$. The truth conditions of such propositions are straightforward to describe:

(8) $prop(s, \sigma)$ is true iff $s \models \sigma$

Characterizing situations by means of situation types allows for a fine-grained, but intentional theory of propositions. Thus, the sitsemian theory of propositions would distinguish, for instance, the propositions associated with (9a,b), uttered, say, when observing the graves of two great French composers:

(9) a. Marais is identical with himself.

b. Poulenc is identical with himself.

c. $prop(s_{fr-pantheon}, \langle\langle SelfIdentical; marais\rangle\rangle)$

d. $prop(s_{fr-pantheon}, \langle\langle SelfIdentical; poulenc\rangle\rangle)$

But it is not overly fine-grained so as not to support indexical inference or translation. Thus, the theory would identify the content of the Arabic utterance (10a) and the Hebrew utterance (10b):

(10) a. ElQuds hadi'a.

b. yerushalayim regu'a.

c. $prop(s_{jlem}, \langle\langle CALM; loc : Jerusalem\rangle\rangle)$

Moreover, by assuming a proposition has a situation as a component, the potential for developing a straightforward account of event anaphora, as in (11) emerges. An assertoric utterance enables subsequent anaphoric reference to an event, even if the assertion is not accepted, as in (11c). This is of course another facet of the intentionality of propositions we mentioned above:

(11) a. A: My back tyre exploded. Two minutes later it started to rain.

b. A: Jo and Mo got married yesterday. It was a wonderful occasion.

c. A: Jo's arriving next week. B: No, that's happening in about a month.

Indeed, for whatever it is worth, this type of representation for utterances jives well with psychological work on memory (see e.g. (Fletcher, 1994) for a review), which argues that the two robust memory traces from an utterance are (a) the *situational model* and (b) the *propositional text base*. The former is a representation which integrates various modalities (e.g. visual and linguistic stimuli), whereas the latter differs from the surface form of an utterance for instance in that referents have been resolved. Of course by positing a situational component in propositional representation a new resolution problem emerges, additional to *inter alia* nominal and temporal reference. How humans deal with this problem in conversation is still to a large extent unexpolored.[6]

3. Motivation for situation types?

What, then, are the survival prospects of the situation/situation-type/proposition trichotomy, which collapses into a dichotomy or even a single point in most other theories? Actually, the main focus needs to be on the situation type/proposition distinction—situation types undoubtedly being the most theory internal entity of the three and whose natural environment is under the severest existential threat. I start by considering some motivation for the proposition/sit-type distinction: the first derives from an argument by Barwise, which I will suggest is problematic. The second argument, which I subscribe to, was offered by Ginzburg and Sag (2000). The situation-type/proposition distinction underpins one of the fundamental claims of Ginzburg and Sag (2000)—that questions denote *propositional* abstracts. I will review some evidence for this claim.

3.1. Facts = Factual situation types?

It has been common among situation semanticists to use the terminology 'facts' for situation types supported by at least one situation. This terminology invites a significant ontological identification, which Barwise (1989b) sought to use as motivation for situation types. There is a significant literature initiated by philosophers such as Vendler which indicates that facts qua denotata of NPs such as 'the/a/that

[6] Though see experimental work by Tanenhaus and colleagues on the resolution of definites, e.g. (Brown-Schmidt et al., 2003) for an example of precisely such an investigation.

fact' should not be identified with (true) propositions (see in particular (Vendler, 1972; Peterson, 1997; Ginzburg and Sag, 2000)). For instance, (12b) show that truth/falsity is not predicable of a POSS-gerund, which occurs in a factive context in (12a). (12c,d) show that a truth/falsity–denoting NP obeys substitutivity under 'believe', but not under a factive verb such as 'remember':

(12) a. Tony's having savaged the party distressed the member for Tooting.

b. # Tony's having savaged the party was true/false.

c. The claim is that Jo left. Bo believes that claim. Hence, Bo believes that Jo left.

d. The claim is that Jo left. Bo remembers that claim. # Hence, Bo remembered that Jo left.

As Ginzburg (1993) points out, there is, however, an intrinsic problem with this identification of "philosophers' facts" with the sitsemian facts. For this identification to be motivated, we would be required to find a striking semantic difference in terms of their 'situational grounding' between the objects of belief and assertion and the objects of knowledge or discovery. This given that in situation semantics the former are taken to be (situationally relativized) austinian propositions whereas the latter are absolute, 'non-perspectival' types. But there is no evidence for such a distinction.

3.2. The Frege-Searle propositional content hypothesis

Speech Act Theory (see e.g. (Searle, 1969; Searle and Vanderveken, 1985)), is the framework of choice for much influential work on dialogue (see e.g. (Cohen and Perrault, 1979; Allen and Perrault, 1980; Litman and Allen, 1987; Allen, 1995). Speech Act Theory embodies an important insight, namely the need to associate with utterances an *illocutionary content*, i.e. a content which embeds a semantic entity such as a proposition or question under a predicate that represents the current conversational move (*assert, ask* etc). However, the ontological perspective of most Speech Act work still draws on a fundamental claim of (Frege, 1918), much trumpeted by Searle, namely that:

(13) Assertions, polar queries, and commands differ on the level of illocutionary force, but share the same descriptive/propositional content (the Frege-Searle propositional content hypothesis(FSPCH)).

Concretely, the claim is this: uttered in the same context, declarative, interrogative, and imperative variants as in (14) have the same (descriptive/propositional) content, namely some proposition p; the difference between these potential utterances, on this view, is that (14a) will be used to assert p, whereas (14b) will be used to ask p, and (14c) to command p:

(14) a. Bo will go away. (Content: Assert(A,B,p))

b. Will Bo go away? (Content: Ask(A,B,p))

c. Go away Bo! (Content: Command(A,B,p))

The FSPCH encodes a plausible intuition, which still constitutes an article of faith among philosophers. There are, however, various considerations that indicate that the FSPCH cannot be maintained. I mention here a subcase of the FSPCH, namely the identification of propositions and (polar) questions. There are also problems with semantically identifying propositions and the denotata of imperatives. For details see (Ginzburg and Sag, 2000), section 3.2.

If a polar interrogative denotes a proposition it should be assertible and bear a truth value, neither of which is the case:

(15) a. I'm going to make one claim: #Did Bo leave?

b. #It is true/false whether Bo left.

Moreover, a polar interrogative utterance should be disquotable using a 'that clause'. In fact, such a disquotation is not possible, but requires instead the complementizer 'whether':

(16) a. A: Did Bo leave?

b. A asked whether/that Bo left.

That this syntactic distinction has denotational consequences is illustrated in (17). (17a) differs from (17b) in allowing for the possibility that Jo didn't leave:

(17) a. Bo knows whether Jo left.

b. Bo knows that Jo left.

Indeed in much AI work including the references given previously, *wh*-interrogatives are also interpreted as propositions, with the *wh*-phrases functioning as definite descriptions. Thus, (18a) is interpreted as

(18) a. Who left?

b. the x: left(x)

There are, similarly, a variety of arguments against identifying the denotata of *wh*-interrogative sentences with propositions. One such argument, due to (Karttunen, 1977), derives from the existence of a class of predicates which embed interrogative but not declarative complements:

(19) a. Brooke asked/wondered/investigated who left.

b. #Brooke asked/wondered/investigated that Drew left.

(20) a. Who wins the race depends upon/is influenced by who enters it.

b. #That Jo will win the race depends on/is influenced by that Mary didn't show up.

These sorts of complement selection patterns are cross-linguistically stable and reflect fundamental lexical semantic properties of the embedding predicates (for details see (Ginzburg and Sag, 2000)). Karttunen's argument constitutes one of the starting points of an approach to semantics, which countenances an ontological distinction between propositions and questions, the denotata of interrogative clauses.

Given arguments of the type presented above, it is clear that the FSPCH cannot be maintained. And yet, a weak version of the FSPCH is needed since, as (21) illustrates, quantified NPs and certain adverbs are possible in all three semantic environments. Hence, the ontology must provide a semantic unit which constitutes the input/output of such adverbial modifiers and of NP quantification:[7]

(21) a. Everyone vacated the building.

b. Did everyone vacate the building?

c. Everyone vacate the building!

[7] To make this concrete—the assumption that the denotation of imperatives is of a type distinct from t (however cashed out) is difficult to square with (a simplistic implementation) of the received wisdom that NPs such as 'everyone' are of type $< e, t, t >$. If the latter were the case, composing 'everyone' with 'vacate the building' in (21c) would yield a denotation of type t.

(22) a. Kim always wins.

b. Does Kim always win?

c. Always wear white!

A good candidate for this are situation types, as we will see in sections 4.

3.3. An explanatory benefit

Let me point now to an explanatory benefit that arises from the existence of a situation-type/proposition distinction. This derives from interrogatives. In much computational work and some theoretical work, interrogatives are taken to denote n-ary λ-abstracts:

(23) a. Who left $\mapsto \lambda x.left(x)$

b. Who saw who $\mapsto \lambda x, y.see(x, y)$

There is much to recommend about this strategy—it offers the basis for a theory of the 'short answers' characteristic in responses to queries (A: Who left? B: Bo) and can underpin a theory of the various answerhood relations semantic theory requires (resolving answerhood, aboutness answerhood etc). However, in most ontological settings, this strategy seems to be highly problematic. It requires us to identify questions with (what are commonly taken to be) the denotations of verbs, common nouns, and adjectives:

(24) a. left $\mapsto \lambda x.left(x)$

b. see $\mapsto \lambda x, y.see(x, y)$

As data like (25a,b) shows, identifying questions with properties seems quite counterintuitive:

(25) a. Some man is happy.
So we know that happiness and manfulness are not incompatible.
#So we know that the question of who is happy and who is a man are not incompatible.

b. A: What was Bill yesterday?
B: Happy.
B: #The question of who is happy.

Ginzburg and Sag (2000) point out that a straightforward solution to this problem exists in a sitsemian ontological setting: verbs, common nouns, and adjectives are taken to denote situation-type abstracts, whereas questions denote propositional abstracts.

Wait. But is there *positive* evidence that questions are *propositional* abstracts, as opposed to any other type of abstract? (Ginzburg and Sag, 2000) provide a concrete argument for the view, based on the distribution of *wh-in situ* phrases in English. Interestingly, in declarative clause-types, that in the absence of a *wh-phrase* denote propositions, the occurrence of such phrases leads to an ambiguity between two readings: a 'canonical' use which expresses a direct query and a use as a reprise query to request clarification of a preceding utterance. In all other clause types, ones which denote outcomes (26d), questions (26e), or facts (26f) the ambiguity does not arise, only a reprise reading is available:[8,9]

(26) a. The bagels, you gave to who? (can be used to make a non-reprise query.)

b. You gave the bagels to who? (can be used to make a non-reprise query.)

c. Who talked to who? (can be used to make a non-reprise query.)

d. Give who the book? (can be used ONLY to make a reprise query.)

e. Do I like who? (can be used ONLY to make a reprise query.)

f. What a winner who is? (can be used ONLY to make a reprise query.)

((Ginzburg and Sag, 2000), example (72), p. 282)

The conclusion of Ginzburg and Sag (2000) is that questions can only be built from within a proposition–denoting environment. In other words, they are *propositional* abstracts.

[8] Ginzburg and Sag (2000) argue that (wh-phrase-less) imperative and subjunctive clauses denote a class of entities they dub *outcomes*, more on which in section 4 below. They also suggest that polar interrogatives denote questions, and exclamative clauses denote (Vendlerian) facts.

[9] *a priori* one might expect (26d), for instance, to have a reading as a direct question paraphrasable as *who should I give the book to?* if one could simply abstract over the *wh*-parameter within an 'open outcome'.

4. Situational Universes with Abstract Entities, type theoretically

In order to develop a formal account of data such as (21), (22), and (26) mentioned in the previous section, one needs to make reference to an ontology that contains all the relevant entities. Ginzburg and Sag (2000) developed such an ontology, dubbed a *Situational Universe with Abstract Entities* (SU+AE). The strategy for developing SU+AEs was very much in line with the strategy of Barwise and Perry's (5). This was implemented in the AFA-based framework of Seligman and Moss 1997. Simplifying somewhat, an SU+AE is an extensional relational structure of the following type:

(27) $[\ \mathcal{A}, Possibility, Proposition, Outcome, Fact, True, Fulfill, \rightarrow_{prop}\ ]$

Let me gloss the key notions involved here: $\mathcal{A}$ is a λ-situation structure (λ-SITSTR). That is, a situation structure closed under simultaneous abstraction.[10] A situation structure (SITSTR) is a universe which supports a basic set theoretic structure. It contains among its entities a class of spatio-temporally located situations and a class of situation types. Proposition, Possibility, and Outcome are sorts whose elements represent, respectively, the propositions, possibilities, and outcomes of the universe.[11] Following our discussion in section 3.1, we also posit a property *Fact*, applicable to the class of possibilities. Those possibilities that are factual, as determined by the predicate $Fact$, will constitute the facts of the universe. Analogously, there will be properties *True* and *Fulfill*, which capture the notions of truth and fulfilledness for propositions and outcomes; $\rightarrow_{prop}$ is a notion of entailment defined for propositions.

Underpinned by SU+AEs Ginzburg and Sag (2000) developed accounts of ontologically intensive data like (21), (22), and (26). However, although no significant empirical problems beset these accounts, there are foundational issues to contend with. For a start, the account in (Ginzburg and Sag, 2000) has a schizoid nature: the SU+AE is presented in two distinct fashions, one purely set theoretic, the other in terms of typed feature structures (TFSs). The TFS-based account is the

[10] For every element $a \in |\mathcal{S}|$ and every set $B \subset |\mathcal{S}|$, the simultaneous abstraction $\lambda B.a$ exists. What this amounts to precisely need not detain us for the moment, since I will offer a precise explication of such a notion in type theoretic terms below. Suffice it to say that an abstract $\lambda B.\tau$ is a structured object that arises by an operation which takes as input an entity τ of the universe and a (possibly empty) set of its components B.

[11] Vendlerian facts are taken to be a subclass of the possibilities.

one used in building up the grammar and usable in computational applications, whereas the pure set theoretic formulation constitutes a semantics for the TFS presentation.[12] Furthermore, neither version of the SU+AE readily provide accounts of role-dependency that has become *de rigeur* in recent treatments of anaphora and quantification on which much semantic work has been invested in frameworks such as Discourse Representation Theory and Dynamic Semantics. Lastly, it is interesting to consider to what extent the construction of fine grained ontologies needed for current purposes *depends* on using the special purpose set theoretic techniques (e.g. for modelling abstraction) of (Seligman and Moss, 1997).

These concerns can be allayed by using a type theoretic framework like that built up in Cooper (this journal). Ever since Ranta's pioneering work (Ranta, 1994), there has been interest in using constructive type theory (CTT) (often referred to as Martin-Löf Type Theory (MLTT)) as a framework for semantics (see e.g. (Fernando, 2001; Krahmer and Piwek, 1999)). CTT offers theoretically satisfying tools for dealing with role dependence that enable accounts of anaphora and quantificational phenomena to be developed. Its provision of entities at both levels of tokens and types allows one to combine aspects of the TFS world and the set theoretic world, obviating the need for the two formulations. Indeed, in a number of papers, including Cooper (1998, this journal), Robin Cooper has shown that there are significant commonalities between situation semantics and a version of CTT with records (Type Theory with Records (TTR)) and that the latter allows for a perspicuous interpretation of notions from the former. Drawing heavily on this, my aim in the remaining sections of the paper is to show how SU+AEs can be located within a type theoretic universe of the kind built up in Cooper (this journal) and how they can be used to capture certain basic ontological facts.[13]

4.1. Basics of Type Theory

CTT is a proof–theoretic framework initiated in the 1970s by Per Martin Löf, based on earlier work by intuitionist logicians. The version used here is the CTT with records and record types ((Betarte and Tasistro, 1998; Kopylov, 2003; Coquand et al., 2003)). The most fundamental

[12] Without a separate semantics we agree with Penn (2000) who says (in discussing a related set of issues), 'At this point, feature structures are not being used as a formal device to represent knowledge, but as a formal device to represent data structures that encode formal devices to represent knowledge'. (Penn, 2000), p. 63.

[13] A companion piece (Ginzburg, 2005) details how the TTRfied situation semantics framework can be used to recast the theory of questions of Ginzburg and Sag (2000) in a more straightforward way.

notion of CTT is the typing *judgement* $a : T$ classifying an object a as being of type T. This can be seen as a generalization of the situation semantics judgement $s \models \sigma$, generalization in that not only situations can figure as subjects of typing judgements. Note that the theory provides the objects and the types, but this form of judgement, as well as other forms are metatheoretical. Examples are given in (28). (28a-c) are typing judgements that presuppose the existence of types SIT, IND, REL, whose identity can be amplified. (28d) is the direct analogue of the situation semantics statement $s \models \langle\langle RUN; b, t\rangle\rangle$; here run(b,t) is a proof type :[14]

(28) a. s : SIT

b. b: IND

c. run : REL

d. s : run(b,t)

A highly useful innovation in the version of CTT introduced by (Betarte and Tasistro, 1998) is the introduction of records and record types. A record corresponds to a number of kinds of entities in other semantic theories: the most lowly creature one might liken it to is a variable assignment, but it also bears significant resemblances to a typed feature structure and to what used to be called in situation semantics an *abstract situation*. Technically, all a record is is an ordered tuple of the form (29), where crucially each successive field can depend on the values of the preceding fields:

(29) $$\begin{bmatrix} l_i = k_i \\ l_{i+1} = k_{i+1}(l_i) \ \ldots \\ l_{i+j} = k_{i+j}(l_i, \ldots, l_{i+j-1}) \end{bmatrix}$$

Together with records come record *types*. Technically, a record type is simply an ordered tuple of the form (30), where again each successive type can depend on its predecessor types within the record:

(30) $$\begin{bmatrix} l_i : T_i \\ l_{i+1} : T_{i+1}(l_i) \ \ldots \\ T_{i+j} : T_{i+j}(l_i, \ldots, l_{i+j-1}) \end{bmatrix}$$

[14] 'proof' can be equally glossed as 'observation' or even 'situation', as explained by (Ranta, 1994); the source of the 'proof-based' terminology is CTT's initial use as a foundation for mathematics.

Record types allow us to place constraints on records: the basic typing mechanism assumed is that a record r is of type RT if all the typing constraints imposed by RT are satisfied by r. More precisely,

(31) The record:

$$\begin{bmatrix} l_1 & = & a_1 \\ l_2 & = & a_2 \\ \dots & & \\ l_n & = & a_n \end{bmatrix} \text{ is of type: } \begin{bmatrix} l_1 & : & T_1 \\ l_2 & : & T_2(l_1) \\ \dots & & \\ l_n & : & T_n(l_1, l_2, \dots, l_{n-1}) \end{bmatrix}$$

iff $a_1 : T_1, a_2 : T_2(a_1), \dots, a_n : T_n(a_1, a_2, \dots, a_{n-1})$

Crucially, not all the fields in r need to be 'disciplined' by RT. Thus, for example, the record in (32a) is of all the types (32b-e). Indeed, all records are of the empty type (32e), the type that imposes no constraints:

(32) a. $\begin{bmatrix} \text{r} = \text{bo} \\ \text{t} = \text{2pm, Dec 20} \\ \text{l} = \text{batumi} \end{bmatrix}$

(b) $\begin{bmatrix} \text{r} : \text{Ind} \\ \text{t} : \text{Time} \\ \text{l} : \text{Loc} \end{bmatrix}$ (c) $\begin{bmatrix} \text{r} : \text{Ind} \\ \text{t} : \text{Time} \end{bmatrix}$ (d) $\begin{bmatrix} \text{r} : \text{Ind} \end{bmatrix}$ (e) $\begin{bmatrix} \end{bmatrix}$

4.2. Connecting to the Real World: situations and their types

The preceding section gave a taste of the basic entities of TTR. My main aim in what follows is to show how an SU+AE can be found with fairly minimal effort within the universe defined by TTR. What then is the Type Theoretic World? Cooper (this journal) offers essentially the following answer:[15]

(33) **Type Theoretic World (Cooper (this journal), simplified)**

$\text{TYPE} = \langle\, \text{Type}^n, \text{BasicType}, \text{ProofType}^n, \text{RecType}^n, \langle A, F^n \rangle \rangle$

a. Type^n is the set of types of order n, built up recursively using type construction operations.

[15] This is a simplified description of Cooper's proposal, which the careful reader would do well to consult.

b. BasicType: IND, TIME, LOC, ...

c. ProofType^n ("interface with external reality"): tuples consisting of entities [from the model] and predicates.

d. RecType^n: set of records, record types defined with respect to a set of objects used as labels.

e. $\langle A, F^n \rangle$ is a model (assigning entities to BasicType, and tuples to ProofType^n).

As with SU+AEs, one can recognize here the sitsemian strategy Barwise and Perry allude to in (5). The universe is connected to the real world via the proof types and the model. This latter grounds the basic types. From these beginnings, arise structured objects via two recursive mechanisms, type construction and record cutting[16].

Let us consider first how situations/events and situation types fit in this ontology. Proof types play a role akin to (atomic) situation types in situation semantics, serving as the smallest particles of external reality. Combining these into record types allows us to form 'molecules' of external reality. Assuming the existence of basic types TIME and LOC(ation), one could offer (34) as the most rudimentary notion of situation, namely that it is a record which carries information about spatio-temporal extent:

(34) $$\text{SIT} =_{def} \begin{bmatrix} \text{time} & : & \text{TIME} \\ \text{loc} & : & \text{LOC} \end{bmatrix}$$

The type of a situation with a woman riding a bicycle would then be the one in (35a). A record of this type (a *witness* for this type) would be as in (35b), where the required corresponding typing judgements are given in (35c):

(35) (a) $$\begin{bmatrix} \text{x: IND} \\ \text{c1: woman(x)} \\ \text{y: IND} \\ \text{c2: bicycle(y)} \\ \text{time : TIME} \\ \text{loc:LOC} \\ \text{c3: ride(x,y,time,loc)} \\ \end{bmatrix}$$ (b) $$\begin{bmatrix} \dots \\ \text{x} = \text{a} \\ \text{c1} = \text{p1} \\ \text{y} = \text{b} \\ \text{c2} = \text{p2} \\ \text{time} = \text{t0} \\ \text{loc} = \text{l0} \\ \text{c3} = \text{p3} \\ \dots \end{bmatrix}$$

[16] I assume this is the right term to describe the emergence of a record/record type.

(c) a:IND; p1: woman(a); b: IND; p2: bicycle(b); t0 : TIME; l0 : LOC;p3: ride(a,b,t0,l0);

A theory of situations requires various topological, physical and other constraints to be imposed on the universe of records, as explained in more detail by Cooper (this journal).

4.3. Propositions in TTR

The first abstract entity we consider in the universe is the class of propositions. In fact, as I noted above, standardly type theory takes judgements such as $a : T$ as metatheoretical but does not countenance propositional entities as such. I have suggested above that the Austinian notion of propositions developed in situation semantics has a number of positive characteristics—its size of grain seems defensible, it can underpin a theory of event anaphora, and its combination of (event/situation) tokens and (event/situation) types is suggestive of a cognitive construal in terms of memory traces. TTR offers a straightforward way of modelling Austinian propositions using records. A proposition is a record of the form in (36a). The type of propositions is the record type (36b):[17]

(36) a. $\begin{bmatrix} \text{sit} & = & r_0 \\ \text{sit-type} & = & T_0 \end{bmatrix}$

b. Prop $=_{def}$ $\begin{bmatrix} \text{sit} & : & \text{Record} \\ \text{sit-type} & : & \text{RecType} \end{bmatrix}$

The correspondence with the situation semantics conception is quite direct. We can define truth conditions as in (37a), which we shall sometimes notate as in (37b)

(37) a. A proposition $p = \begin{bmatrix} \text{sit} & = & s_0 \\ \text{sit-type} & = & ST_0 \end{bmatrix}$ is true iff $s_0 : ST_0$

b. p : True

Continuing in a sitsemian spirit, one can now import an *essentially* intuitionist logic to underpin the Boolean structure of the space of propositions. (38a,b) are operations on types typically assumed in CTT[18], whereas (38c) is from Cooper (this journal), which in turn goes back to classical situation semantics:

[17] One could, if one so wished, require *sit-type* to be an extension of the type SIT postulated in (34).

[18] See e.g. (Ranta, 1994), Chapter 2.

(38) a. $\neg T_0$ is the type $T_0 \rightarrow \bot$: the type $\neg T_0$ is witnessed, one needs to show that every situation of type T_0 is also of type $\bot$.

b. $T_1 \wedge T_2$: to show that $T_1 \wedge T_2$ is witnessed, one needs a pair $< p1, p2 >$ where p_1 is of type T_1 and p_2 is of type T_2.

c. $T1 \vee T2$: a witness for $T1 \vee T2$ is an entity p_0 where p_0 is of type T_1 or p_0 is of type T_2.

Given this, we can define the requisite Boolean operations on propositions:

(39) Given a proposition p $= \begin{bmatrix} \text{sit} & = & r_0 \\ \text{sit-type} & = & T_0 \end{bmatrix}$, its negation is the following record: $\begin{bmatrix} \text{sit} & = & r_0 \\ \text{sit-type} & = & \neg T_0 \end{bmatrix}$

A couple of remarks are worth making: just as in situation semantics, there is a notion of partiality applicable here. If s is : $calm(jerusalem)$, it need not be : calm(london). But this is not enough to allow us to infer that s : $\neg calm(london)$. As a consequence of this the notion of proposition that emerges is non-classical in the sense given in (40a). Of course, it is still sound in the sense given in (40b):

(40) a. false(p) does not imply true($\neg p$)

b. true(p) implies false($\neg p$)

Conjunction may be defined as follows:

(41) Given a proposition p $= \begin{bmatrix} sit & = & r_0 \\ \text{sit-type} & = & T_0 \end{bmatrix}$ and a proposition q $= \begin{bmatrix} sit & = & r_1 \\ \text{sit-type} & = & T_1 \end{bmatrix}$, their conjunction $\bigwedge\{p, q\}$ is the following record:

$$\begin{bmatrix} sit & = & < r_0, r_1 > \\ \text{sit-type} & = & T_0 \wedge T_1 \end{bmatrix}$$

It is straightforward to show that:

(42) p and q are true iff $\bigwedge\{p, q\}$ is true.

Propositional disjunction may be defined as follows:

(43) Given a proposition p = $\begin{bmatrix} sit & = & r_0 \\ \text{sit-type} & = & T_0 \end{bmatrix}$ and a proposition q = $\begin{bmatrix} sit & = & r_0 \\ \text{sit-type} & = & T_1 \end{bmatrix}$, their disjunction $\bigvee\{p, q\}$ is the following record:

$$\begin{bmatrix} sit & = & r_0 \\ \text{sit-type} & = & T_0 \vee T_1 \end{bmatrix}$$

Note that $\bigvee$ here is defined solely for propositions that have the same situational component.[19]

It is straightforward to show that:

(44) Either p or q is true iff $\bigvee\{p, q\}$ is true.

The final notion that needs mentioning concerning propositions is entailment. With propositions as records consisting of a record and a record type field, a natural (pre)ordering arises that derives from the corresponding notions on records and record types. Whether one thinks of records as graphs (e.g. Cooper (this journal)) or as functions (e.g. (Kopylov, 2003)), one can use standard set theoretic notions of inclusion to order the record domain. One of the key features of record types is the *subtyping property* exemplified above in (32)(see also (Betarte and Tasistro, 1998), section 3.2.5, (Kopylov, 2003), section 3), and given here as (45):

(45) If for any label $l_i : T_0$ that occurs in record type RT_1, $l_i : T_1$ occurs in record type RT_2, where $T_1 \sqsubseteq T_0$, then $RT_2 \sqsubseteq RT_1$

If r_2 is a more inclusive record than r_1, then the truth of the proposition $\begin{bmatrix} \text{sit} & = & r_1 \\ \text{sit-type} & = & T_1 \end{bmatrix}$ entails the truth of the proposition $\begin{bmatrix} \text{sit} & = & r_2 \\ \text{sit-type} & = & T_1 \end{bmatrix}$, since all the constraints holding of r_1 extend to r_2. The opposite direction applies to record types: if $RT_0 \sqsubseteq RT_1$, then the truth of the proposition $\begin{bmatrix} \text{sit} & = & r_1 \\ \text{sit-type} & = & RT_0 \end{bmatrix}$ entails the truth of the proposition $\begin{bmatrix} \text{sit} & = & r_1 \\ \text{sit-type} & = & RT_1 \end{bmatrix}$. This discussion can be

[19] This has some linguistic justification from the observation, see (Grice, 1989; Simmons, 2002), that disjunction only works if the two juncts 'concern a single issue'.

summarized as the following sufficient condition for entailment between propositions:

(46) $\begin{bmatrix} sit & = & r_0 \\ \text{sit-type} & = & RT_0 \end{bmatrix}$ entails $\begin{bmatrix} sit & = & r_1 \\ \text{sit-type} & = & RT_1 \end{bmatrix}$ if $r_1 \supseteq r_0$ and $RT_0 \sqsubseteq RT_1$.

4.4. Abstraction and Abstract Entities

Propositions entered into the universe courtesy of record cutting operations. Their recursive structure was further underpinned by Boolean type constructors. In order to deal with the abstract entities that remain to be explicated, questions and outcomes,[20] we need to appeal to two more constructors, the function type constructor and the unique type constructor:

(47) a. **function types**: if T_1 and T_2 are types, then so is $(\mathrm{T}_1 \rightarrow \mathrm{T}_2)$, the type of functions from elements of type T_1 to elements of type T_2. f:$(\mathrm{T}_1 \rightarrow \mathrm{T}_2)$ iff the domain of f is $\{a|a : T_1\}$ and the range of f is a subset of $\{a|a : T_2\}$

b. **The unique type**: if T is a type and $x : T$, then T_x is a type. $a : T_x$ iff $a = x$.

The functional type constructor is deceptively familiar from Montague Semantics. In the presence of record typing, this becomes a far richer notion than classical unary λ-abstraction. It can be simultaneous and restricted, i.e. it allows for multiple entities (including null many) to be abstracted over simultaneously while encoding restrictions. More specifically, since record types allow for multiple labels, the domain type of the abstract effects simultaneous abstraction 'from' the range type. Moreover, because of the successively dependent nature of the labels, restrictions can be imposed which apply to one or more labels. The simultaneous abstract in (48a) can be modelled as the function in (48b), which has the type in (48c) (assuming some typing given in terms of the types T_i for x_i):

(48) a. $\lambda\{x_1, \ldots, x_k\}\phi(x_1, \ldots, x_k)$
$[\psi_1(x_1, \ldots, x_{n_1}), \ldots, \psi_k(x_k, \ldots, x_{n_k})]$

[20] For reasons of space I will not discuss possibilities and facts.

b. $\begin{bmatrix} x_1 = a_1 \\ \dots \\ x_k = a_k \\ c_1 = p_1 \ \dots \\ c_k = p_k \end{bmatrix} \mapsto \phi(a_1, \dots, a_k)$

c. $\mathrm{r} : \begin{bmatrix} x_1 : T_1 \\ \dots \\ x_k : T_k \\ c_1 : \psi_1(x_1, \dots, x_{n_1}) \\ \dots \\ c_k : \psi_k(x_k, \dots, x_{n_k}) \end{bmatrix} \rightarrow \phi(r.x_1, \dots, r.x_k)$

With this in hand, we can turn to briefly explicating outcomes and questions.

The class of outcomes was introduced in (Ginzburg and Sag, 2000), following (Portner, 1997), to describe goals and serve as the denotata of imperatives, subjunctives and (certain uses of) infinitives:

(49) a. Sit!

b. Bo demands that Mo sit.

c. Mo's goal is to leave.

Outcomes are closely related to propositions, with the main difference being temporal—outcomes are intrinsically futurate, but with a temporal dimension which is typically unanchored (at speech time):

(50) a. Go home. You can *then* take a nap.

b. Mo requested Bo to resign. He never did.

Truth is not applicable to such entities, what is applicable is the notion of being *fulfilled*. We can explicate this in an Austinian fashion—as records whose fields are a situation and a situation type–abstract, of which a temporal argument has been abstracted away. We define the type Irrealis—temporal abstracts over the class of record types:

(51) $\text{Irrealis} =_{def} (\left[\mathrm{t} : \mathrm{Time}\right])\mathrm{RType}$

An outcome will be a record of the form in (52a), the type Outcome given in (52b):

(52) a. $\begin{bmatrix} \text{sit} & = & r_0 \\ \text{irr-sit-type} & = & p_0 \end{bmatrix}$

b. Outcome $=_{def}$ $\begin{bmatrix} \text{sit} & : & \text{Record} \\ \text{irr-sit-type} & : & \text{Irrealis} \end{bmatrix}$

The fulfilledness conditions of an outcome $\begin{bmatrix} \text{sit} & = & s_0 \\ \text{irr-sit-type} & = & p_0 \end{bmatrix}$ involve the existence of a situation s_1 which is situated temporally after s_0 such that s_1 witnesses an instantiation of p_0. This is the sense in which outcomes are 'futurate'. The witnesses for a given outcome's Fulfilledness can be characterized in terms the following family of record types:[21]

(53) For an outcome o1 $= \begin{bmatrix} \text{sit} = s_0 \\ \text{irr-sit-type} = p_0 \end{bmatrix}$

Fulfillers(o1) $=_{def}$

$$\begin{bmatrix} s_1 : \text{Record} \\ fulfill-time : \text{Time} \\ c_1 : anterior(s_0, s_1) \\ \text{p} = \begin{bmatrix} \text{sit} = s_1 \\ \text{sit-type} = p_0(\text{fulfill-time}) \end{bmatrix} : \text{True} \end{bmatrix}$$

(54) exemplifies the content of an imperative use. Included is the basic presupposition of such a use, that the desired outcome is not fulfilled at speech time:[22]

(54) Mo: Bo, leave!

[21] The notation in (i) is shorthand for (ii). This exemplifies the appeal to the unique type constructor introduced in (47b), which requires (iii):

(i) p = a : T

(ii) p : T_a

(iii) p : T and p = a

[22] Notation such as $\forall f$: Fulfillers(o)[...] is shorthand for the standard type theoretic explication of universal statements in terms of functional types $(\begin{bmatrix} \text{f} : \text{Fulfillers(o)} \end{bmatrix})\begin{bmatrix} \dots \end{bmatrix}$.

$$\begin{bmatrix} \text{spkr} : \text{Ind} \\ \text{addr} : \text{Ind} \\ \text{utt-time} : \text{Time} \\ \text{o} = \begin{bmatrix} \text{sit} = \text{s}_0 \\ \text{irr-sit-type} = (\text{r} : \left[\text{t} : \text{Time}\right])\left[\text{c1: leave(b,r.t)}\right] \end{bmatrix} : \text{Outcome} \\ \text{c2} : \forall f : \text{Fulfillers(o)}\ \neg[\text{utt-time} = \text{f.fulfill-time} : \text{Time}\ ] \\ \text{cont} : \text{Command(spkr,addr,utt-time,o)} \end{bmatrix}$$

Given the existence of sitsemian-like propositions, a proposition/situation-type-like distinction, and a theory of simultaneous abstraction, it is straightforward to develop a theory of questions as propositional abstracts. In the current set up propositional abstracts are functions from records to propositions. (55) exemplifies the denotations we can assign to a polar, a unary wh, and a binary wh–interrogative. The polar question is a constant function whose value is the queried proposition, the unary question ranges over instantiations by persons of the proposition $run(x)$, the binary question ranges over instantiations by pairs of persons x and things y of the proposition $greet(x, y)$:

(55) a. Did Bo run

b. TTR representation: maps records $\text{r} : \text{T}_0 = \left[\ \right]$

into propositions of the form $\begin{bmatrix} \text{sit} & = & r_1 \\ \text{sit-type} & = & \left[\text{c} : \text{run(b)}\right] \end{bmatrix}$

c. who ran

d. TTR representation: maps records $\text{r} : \text{T}_{who} = \begin{bmatrix} \text{x} & : & \text{Ind} \\ \text{rest} & : & \text{person(x)} \end{bmatrix}$ into propositions of the form $\begin{bmatrix} \text{sit} & = & r_1 \\ \text{sit-type} & = & \left[\text{c} : \text{run(r.x)}\right] \end{bmatrix}$

e. who greeted what

f. TTR representation: maps records r : $T_{who,what}$

$$= \begin{bmatrix} \text{x} & : & \text{Ind} \\ \text{rest1} & : & \text{person(x)} \\ \text{y} & : & \text{Ind} \\ \text{rest2} & : & \text{thing(y)} \end{bmatrix}$$

into propositions of the form $\begin{bmatrix} \text{sit} & = & r_1 \\ \text{sit-type} & = & \left[\text{c} : \text{greet(r.x,r.y)}\right] \end{bmatrix}$

Given the polymorphic nature of TTR, the difficulty of defining a type Question that beset earlier attempts at a theory of questions as propositional abstracts can be overcome, see (Ginzburg, 2005) for details. Here I will restrict myself to sketching a type theoretic explication of the relation of *resolvedness*, a linguistically significant relation that relates questions, propositions, and outcomes. As discussed in some detail in (Ginzburg, 1995b), resolvedness is to questions, what provability is to propositions. In particular, various NL predicates that combine syntactically with an interrogative complement, semantically predicate not of the question denoted by this complement, but of a fact that resolves that question. Such *resolutive* predicates include 'tell', 'know', 'discover', and 'forget'. The resolvedness conditions of polar interrogatives are fairly uncontroversial: a resolving answer needs to entail whichever of p or $\neg p$ is factual, assuming the question is decided:

(56) Bo knows whether p (whether Mo is asleep). Hence, either Jo knows p (that Mo is asleep) or Jo knows $\neg p$ (that Mo is not asleep).

The situation with wh-questions is far more complicated. As discussed in *inter alia* (Boër and Lycan 1985, Ginzburg, 1995a, van Rooy 2003, Asher and Lascarides, 2003), there are various pragmatic factors which seem to come into the picture when evaluating whether a proposition resolves a question, in a given context. These include the goals associated with the interaction and the knowledge states of the conversationalists. To illustrate—whether the inference pattern illustrated in the scenario in (57) is valid depends on precise details concerning Anders' knowledge:

(57) Anders: I wanted to get to Josè's house on the Tube. So I asked Werner where Josè's house is. Werner told me that the house is near Pimlico station. So now I know where Josè's house is.

An analysis of resolvedness needs to integrate semantic constraints that derive directly from the question with agent-relative information. In (58), this latter is cashed out in terms of a relation, not further analysed here, *epistemically-sufficient* that holds between a proposition, an agent, and an outcome. This relation is intended to represent a proposition providing information to an agent that is sufficient for an outcome to be fulfilled. The semantic constraints in (58) concerning the question are essentially a type theoretic reformulation of the relation *potential resolvedness* from (Ginzburg and Sag, 2000): they involve a proposition p entailing either an instantiation of the question or the negative universal. For polar questions this reduces to the characterization in (56), given that a polar question ($[\ ]$)p has the sole instantiation p and so the corresponding negative universal is $\neg p$.

(58) For a question q = (a : A)p(a) ResolvingAnswers(q) $=_{def}$ (p resolves q relative to B's desired outcome o)

$$\begin{bmatrix} \text{p} : \text{Prop} \wedge \text{True} \\ \text{B: Ind} \\ \text{a: A} \\ \text{o} : \text{outcome} \\ \text{p1} = \text{q(a)} \vee \text{p1} = \forall x : A \neg q(x) : \text{Prop} \\ \text{c2} : \text{entails(p,p1)} \\ \text{c3: want(B,o)} \\ \text{c4} : \text{ep-sufficient(p,B, o)} \end{bmatrix}$$

4.5. Concluding Remarks

Building up ontologies that include abstract entities such as propositions and questions are an important task for semantics in the 21st century as in the 19th. In light of the ontological labours we undertook earlier, let us finally return to the *Frege-Searle propositional content hypothesis*(FSPCH) which we initially discussed in section 3.2. Recall that that hypothesis identifies the denotata of a declarative, polar interrogative, and imperative which 'concern the same situation', as in (14), repeated here as (59):

(59) a. Bo will leave.

b. Will Bo leave?

c. Bo, leave!

As we discussed earlier, *identifying* the corresponding proposition, polar question, and outcome is not viable semantically. Nonetheless, the requisite commonality, needed to explicate adverbial modification and nominal quantification, is easy to spell out, given the contents we associate with these sentences uttered in a single context:

(60) a. Bo will leave $\mapsto$
$$\text{Assert(a,b,}\begin{bmatrix}\text{sit} = s_0 \\ \text{sit-type} = \left[\text{c: leave(b,t)}\right]\end{bmatrix}\text{)}$$

b. Will Bo leave? $\mapsto$
$$\text{Ask(a,b, (}\left[\ \right]\text{)}\begin{bmatrix}\text{sit} & = & s_0 \\ \text{sit-type} & = & \left[\text{c : leave(b,t)}\right]\end{bmatrix}\text{)}$$

c. Bo, leave ! $\mapsto$
$$\text{Command(a,b,}\begin{bmatrix}\text{sit} = s_0 \\ \text{irr-sit-type} = (\text{r} : \left[\text{t : Time}\right])\left[\text{c: leave(b,r.t)}\right]\end{bmatrix}\text{)}$$

What is common across the three utterances is the record type $\left[\text{c: leave(b,t)}\right]$.

I have argued that the sitsemian approach to ontological construction helps account for a number of better and lesser worn semantic puzzles, apart from other more general cognitive and computational considerations. At the same time, I have sketched an alternative implemention of this approach in a different logical framework, type theory with records, which one hopes, has the potential for integrating sitsemian insights with the insights of other dynamic semantic frameworks. To the extent that the TTR formalization of SU+AEs is viable it suggests that the results originating in the sitsemian SU+AE are not framework dependent.

The ontology described here satisfies the following requirements:

1. It is *intentional*: providing entities such as propositions and questions which can be shared across participants and languages and enabling us to develop a theory of event anaphora.

2. It is fine-grained: does not run into logical omniscience or Soames' puzzle. It is not too fine grained, so it allows for identity of content across translation or synonymous reformulation.

3. It allows for distinctions to be made between various kinds of 'informational entities', including situations/events, situation types,

propositions, questions, and outcomes. At the same time, commonalities between these entities can be captured.

4. It provides for role dependency as required for developing a theory of anaphora and a theory of abstraction which allows for null, unary, and multiple restricted abstracts. In particular, questions are *propositional* abstracts.

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